

VICTORIA DAM

On the west branch of the  
Ontonagon River, 4.5 miles  
southwest of the Village of  
Rockland on Victoria Dam Road  
Rockland Vicinity  
Ontonagon County  
Michigan

HAER No. MI-49

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD

National Park Service  
Northeast Region  
U.S. Custom House  
200 Chestnut Street  
Philadelphia, PA 19106

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Location: On the west branch of the Ontonagon River,  
4.5 miles southwest of the Village of Rockland on  
Victoria Dam Road, Rockland Vicinity, Ontonagon  
County, Michigan

UTM: 16.329050.5172083  
QUAD: Rockland, MI

Engineers: Holland, Ackerman and Holland  
(Ann Arbor and Chicago)

Contractor: Price Brothers  
(Dayton, Ohio)

Date of  
Construction: 1929-1931

Present Owner: Upper Peninsula Power Company  
(Houghton, Michigan)

Present Use: In 1991, to be partially demolished and the  
remainder submerged

Significance: The reinforced concrete, multiple-arch  
buttressed dam was never a very common type  
in the United States, and it was particularly  
uncommon in the eastern half of the country.  
Very few dams of this type were built after  
1930. Victoria Dam was the best, largest  
example of the multiple-arch dam in Michigan.

Project  
Information: This documentation was undertaken in the  
summer of 1991, after the Federal Energy  
Regulatory Commission (FERC) required the  
Upper Peninsula Power Company (UPPCO) to  
mitigate the adverse effects of a project to  
replace the multiple-arch section of Victoria  
Dam. UPPCO engaged Stone & Webster Michigan,  
Inc. to provide the required documentation.

Larry D. Lankton, Historical Consultant  
Houghton, Michigan

Starting in the 1840s, the Keweenaw Peninsula of Upper Michigan became home to some of the earliest and largest copper mines in the United States. As the companies went deeper each year for their copper-bearing rock, they mechanized more and more operations in an attempt to keep their mining costs down. Prior to 1900, the prime mover that set all the mining and milling machinery into motion was the steam engine. [1] The local mines made almost no use of water power, because at very few sites did rapids or falls coexist with workable mineral deposits. The mines also made scant use of electricity, except for lighting. These conditions began to change, however, early in the twentieth century, as select companies sought out new sources of power that were less expensive and more efficient.

As a direct result of this search, two mining companies turned their attention to the hydro-power potential of the west branch of the Ontonagon River in Ontonagon County. More specifically, they looked for a hydro site in the vicinity of Glenn Falls, located in Section 31, T50N, R39W. Glenn Falls, located in hilly, heavily-timbered country, was about 4 miles upstream of the confluence of the west and middle branches of the Ontonagon River, and about 18 miles up from where the river ran into Lake Superior.

The Victoria Copper Company, whose mine was situated very near the river, was the first to erect major hydraulic works at this site. As the mine expanded in the first few years of the twentieth century, it wanted to end its reliance on coal-fired boilers and steam power. Shipping coal into the Victoria mine was an expensive proposition. After arriving at Rockland, the closest village served by a railroad, the coal had to be put into wagons and then hauled up and down over 4.5 miles of steep grades. To end the Victoria company's dependence on an expensive fuel, in 1902 Thomas Hooper started supervising the construction of hydraulic works on the Ontonagon. At a point about a half-mile above Glenn Falls, workers laid a concrete dam across the river valley. This dam diverted water into a power canal that snaked about 4,000 feet along the northern edge of the valley down to just past Glenn Falls. At this point, the Victoria Copper Company put the water to work in a very novel fashion. [2]

In lieu of erecting a hydroelectric plant beside the river, Victoria erected a hydraulic air compressor there, one designed by Charles H. Taylor of Montreal. In 1903, Thomas Hooper examined a Taylor air compressor in operation at Norwich, Connecticut, and in July of that year Victoria contracted with Taylor for a compressor facility having a capacity of 4,000 horsepower and a guaranteed efficiency of 70 percent or better. Taylor's hydraulic compressor did not use any water wheels,

turbines, or mechanical compressors. Instead, it was "practically automatic" and had "no moving parts."

The heart of the Taylor hydraulic compressor was not a machine, but a large underground chamber blasted out of bedrock more than 300 vertical feet beneath the downstream end of the power canal. Water from the canal flowed into a forebay, which channelled it into three cylindrical shafts leading down to the underground chamber. As the water fell into these shafts, it sucked in air from many small atmospheric intakes. The descending column of water captured air bubbles and carried them down to the the underground chamber. There the air and water separated, and the rising water compressed the captured air against the dome of the underground chamber. The air capacity of the underground chamber, between the water line and its roof, was 80,264 cubic feet. A 24-inch main drew off the compressed air at a pressure of 117 pounds per square inch, while a 12-inch blow-off pipe provided pressure relief. A large inclined shaft returned water from the underground chamber to the river channel. [3]

The Taylor hydraulic compressor at Victoria went into operation in March, 1906. Instead of using electric motors or steam under pressure to drive machinery, Victoria used air under pressure to drive equipment at its mine and stamp mill. The air compressed by the west branch of the Ontonagon drove hoists, pumps, rock drills, rock crushers and stamps, machine and blacksmith shop equipment, a sawmill and a tramroad.

Shortly after the Taylor compressor went into operation, another mining company about 50 miles to the north in Houghton County became interested in its site, and in the potential of the west branch of the Ontonagon to generate hydroelectric power. Copper Range was a holding company that owned several mines and stamp mills, a smelter, and a railroad. [4] In 1906-07 Copper Range contemplated the adoption of electrical power for the purposes of pumping water from its mines, crushing rock, powering underground haulage locomotives, and possibly hoists. By switching from steam to electrical power the company hoped to save about 10,000 tons of coal per year, at a time when coal cost \$3.50 per ton. [5]

On 21 November 1906, Frank W. Denton, the Copper Range's general manager, wrote to William A. Paine, the company's president:

...having heard a great deal about the wonderful water power of the Ontonagon River..., I decided to investigate it somewhat, as, if there was anything to it, the power would be as valuable to us as to anybody else. I accordingly estimated from the map the drainage

area of the river and from the known average rainfall of the region estimated the flow of water into the river. This flow, at times of low rainfall and in dry months, is not large. The figures would indicate that not more than about 50 H.P. could be counted upon per foot of fall. The next question was, How much fall could be obtained. Accordingly, I ...spent Sunday in Rockland and visited the plant of the Victoria, and also walked along the banks of the main river from the junction of its two branches to the bridge at Rockland. We could find no place where a high dam would be possible except with great length and great expense. I therefore figured that the river has not power enough available without tremendous expense to make it worth considering as a source for us. The Victoria plant is located on the branch of the river at a place where there is a fall of about 70 feet in a length of 3,000 feet....I feel...that there is no use in paying any further attention to possible power on the Ontonagon River. [6]

In 1907, Copper Range, acting on the basis of Denton's critical assessment, declined an opportunity to purchase control of the Victoria Copper Company, including its mine, stamp mill, and hydraulic works. Copper Range, rather than investing in any hydro facilities, turned its attention at the time to the construction of a coal-fired generation plant. Meanwhile, the Victoria mine limped along. It regularly lost money from 1908 through 1913, and at times dry conditions allowed for only part-time operation of its hydraulic air compressor. Victoria did better during the World War I years -- the last real boom years that Michigan copper would ever have. But after the war, manufacturers and governments dumped their surplus, stockpiled metal, and the bottom dropped out of the copper market. The Victoria mine, like several in Michigan, closed in 1921 and never reopened. [7]

The Michigan copper industry entered a severe depression in 1921, and only its strongest companies survived and started to achieve economic recovery by the late 1920s. As the region's economic fortunes started to improve, several different parties became interested in the hydroelectric potential of the idled Victoria site. At the start, chief among them was Frank H. Speese, from Whitehall, Michigan. Speese first visited the site in 1925, while on a deer-hunting expedition, and in 1926-27 he began more seriously to study its possibilities and get more persons involved with the effort. [8] To derive early plans for harnessing the river, Speese consulted with various engineering firms. Key among them was the firm of Holland, Ackerman and Holland of Ann Arbor.

Speese and R. K. Holland were not alone in being interested in Victoria. At about the same time, the engineering firm of Stone & Webster examined the hydroelectric potential of the Ontonagon River for the Chicago-based utility, Central Public Service Company -- and the Copper Range company re-entered the picture when its new Michigan manager, William Schacht, had the Fargo Engineering Company of Jackson, Michigan, write a "Report on Proposed Hydro-Electric Developments on the Ontonagon River" for his firm. [9] As some of the early plans for hydro development came together, they usually dealt comprehensively with the Ontonagon River, and not just with the Victoria site. The entrepreneurs and engineers envisioned a series of hydro plants.

In September, 1926, Speese organized the Northern Acquisition Company to study and promote the proposed hydro developments. Speese served as president of the organization; the engineer R. K. Holland served as vice-president; and W. G. Yates of Grand Rapids, a third major investor in the firm, served as secretary-treasurer. Besides conducting feasibility studies, Northern Acquisition immediately secured an option to buy the property of the Victoria Copper Company, and it also secured franchises to furnish power to virtually all of Ontonagon County. In the spring of 1928, W. G. Yates sold out his interest in Northern Acquisition to Harry S. Price, who was with the contracting firm of Price Brothers of Dayton, Ohio. Northern Acquisition, in terms of its top personnel, now had the three key elements needed to launch its proposed project. It had its driving entrepreneur (Speese); its engineer (Holland); and its contractor (Price). [10]

All three men indeed played instrumental roles in building the Victoria hydroelectric plant, but their original firm, Northern Acquisition, was not the company to finish it. Instead, William Schacht of Copper Range encouraged his company to take the primary role in completing the Victoria project. Copper Range combined forces with the Middle West Utilities Company of Chicago to form the Copper District Power Company. (Each of the two firms owned 42.5 percent of the new one.) The Copper District Power Company then acquired the properties and water rights needed for the hydro development from Northern Acquisition, whose principals still kept an interest in the development. Speese owned 15 percent of the Copper District Power Company and served as one of its directors; R. K. Holland's firm engineered Victoria and oversaw its construction; and Price's contracting firm built it. [11]

Copper Range bought into this project because it thought the reviving copper mines on the Keweenaw Peninsula would become

greater users of electrical power in the near future. It hoped not only to use electrical power at its Champion, Trimountain, and Baltic mines, but to sell electricity to other mine firms, especially Calumet and Hecla. Copper Range spearheaded the formation of the Copper District Power Company after it became convinced that a market existed for all the hydroelectric power that could be generated along the full Ontonagon River. In 1930, the Copper District Power Company had ambitious plans:

The property acquired covers the principal lands for the development of seven hydroelectric plants with a total estimated output of one hundred seventy-five million k.w. hours per year of firm power. The Victoria plant [alone] will develop forty-five million k.w. hours. [12]

When construction at Victoria started late in 1929, it was anticipated that this one plant would cost \$1.6 million. Victoria's backers also expected, later, to erect another six hydro plants to accompany Victoria. This system of generating plants would cost, altogether, nearly \$7 million. They would be served by an estimated 219,000 acre-feet of water, coming from a drainage area of 1340 square miles along the Ontonagon River. They would operate off a total head or fall of 580 feet. [13] However, by the time the Copper District Power Company completed Victoria, economic conditions had worsened, not only in the western Upper Peninsula, but across the nation. Although the company brought Victoria on-line as scheduled, the Great Depression further decimated the Keweenaw copper mining industry, and caused the power company to scuttle its plans for other hydro installations in the area.

\* \* \* \* \*

When the principal contracting firm of Price Brothers Company began construction of the dam, penstock and powerhouse, the isolated site and its rugged terrain presented some major transportation problems. Erecting the various components of the Victoria hydroelectric plant required the removal, or excavation, of 80,000 cubic yards of material, and the installation of 22,500 cubic yards of concrete, 2,300 tons of iron and steel, and 731,000 board feet of redwood staves. The two generator rotors destined for the powerhouse weighed 37.5 tons each. Transporting heavy equipment and construction materials to the site proved difficult, because only a gravel road ran up to the dam site from the nearest railroad at Rockland. [14]

The gravel road crossed the Ontonagon River once via a steel truss bridge rated at only a 14-ton load, and in traversing hills the road presented grades as steep as 17 percent. To deliver

materials to the site, workers reinforced the steel bridge by propping it up from underneath, but the heaviest equipment still had to be forded across the river using draglines. A small fleet of trucks moved lighter materials up to the dam site, but Caterpillar tractors pulled the heavier loads.

The building site presented obstacles to rapid transportation, but it did offer several important conveniences or amenities. Some of these were natural, and some were man-made and left behind by the Victoria Copper Company. The site yielded up important natural resources. All the construction lumber needed for concrete forms and the like came from the adjacent forest; it was sawn with portable mills located at or near the site. In a similar fashion, local rock, crushed right at the site, served as coarse aggregate for the concrete.

The contractor made extensive use of the physical plant left behind by the defunct Victoria Copper Company. After a bit of restoration work on the buildings, Price Brothers quartered resident engineers and supervisors in the mine office building, put up 150 men in Victoria's old hotel, and domiciled 50 families in miners' houses. A general store and post office reopened at Victoria. The contractor rehabilitated the mine's blacksmith and machine shops, "where the old equipment was still in place and suitable for most of the drill sharpening, repairing, and other work incidental to construction." [15] And from tailings at the mine's stamp mill, located about 1,000 feet downstream of the dam, workers obtained sand used in mixing concrete.

Of particular importance, Price Brothers made good use of Victoria's Taylor hydraulic air compressor, located just 600 feet downstream of the dam site. Once returned to operation, the compressor "turned out to be an exceedingly valuable adjunct to the construction equipment." It's compressed air powered water pumps, an electrical generating plant, and the machine and blacksmith shops. The old hydraulic air compressor system aided in the erection of Victoria Dam in another way. Besides providing power, it's dam and canal impounded and diverted water from the west branch of the Ontonagon River: "By taking advantage of periods of low flow, it was possible to pass the entire stream through the canal and thus permit the difficult work in the bottom of the gorge to be carried out under nearly dry conditions." [16]

The 675-foot-long structure to be constructed across this gorge had five essential components: two earth-filled embankments, a gated spillway, an intake house, and a multiple-arch concrete dam. The two earthen embankments stood on the extreme southern and northern ends of the structure and tied it

to the sides of the river valley. The northern embankment was the larger of the two, having a maximum height of about 50 feet and a crest running 178 feet long. To protect the embankment from leakage and erosion, it carried a reinforced concrete core wall, and its upstream face was lined with impervious clay.

The northern embankment connected to a reinforced concrete intake structure. The underwater mouth of the intake was protected by a submerged steel trash rack, and was surmounted by a two-story structure that contained the 14-foot-wide by 14.25-foot-high riveted steel intake gate. This rise-and-fall gate, moved by a fixed electric hoist of 40-ton capacity, controlled water flow from the reservoir into the penstock leading to the powerhouse.

The southern embankment connected to a four-bay-wide, concreted spillway. Each bay carried a steel radial gate, 22 feet wide and 12 feet high. These gates regulated the amount of water discharged over the spillway, and thus controlled the height of the water standing in the reservoir. A single overhead, electrically operated traveling hoist raised or lowered the gates. In times of high water, when a maximum amount of water had to be discharged, the gate in each bay could be raised to permit a spillway opening 22 feet wide and 15 feet high. [17]

The dominant feature of the new construction at Victoria was the concrete dam that stood in the deepest part of the gorge and connected the intake house on the northern side of the valley with the gated spillway on the southern side. Holland, Ackerman and Holland's 1928 plans for Victoria dam called for "a single arch concrete structure in the gorge flanked by gravity type abutments." [18] But before construction actually began, the engineering firm opted for a multiple-arch buttressed dam. This represented an unusual choice. Few examples of this dam design existed in Michigan, and Victoria would be the largest. [19] Multiple-arch dams were more commonly found in the American West.

Near the turn of the century, John S. Eastwood, a hydroelectric power engineer, had done much of the pioneering work on the multiple-arch dam. American engineers at the time exhibited a strong preference for gravity dams, a form which relied on material bulk to stabilize the dam and allow it to stand against the pressure of impounded water. Eastwood sought out a different dam design, one that would conserve materials, be safe and economical, and particularly well suited for erection in remote Western locales. [20] His striving for an efficient dam design, one that especially conserved on concrete, led him to the multiple-arch buttressed dam. This dam form consists of two main structural elements: a sloping upstream deck that supports

the impounded water, and buttresses or piers that in turn support the deck and transmit its load down to the foundation.

In the type of dam pioneered by Eastwood, the deck, instead of being formed of flat slabs, is formed of multiple arches of reinforced concrete, usually inclined at about 45 degrees. The slope of the buttress dam allows it to use the vertical component of the water load as a stabilizing force against sliding or overturning. In short, the water standing against the dam helps hold it down, and this means that a buttress dam requires less material than other types of concrete dams. The multiple-arch buttressed dam is materially conservant for other reasons as well. Because the arch form is inherently stronger than a flat slab, it allows for a deck of reduced thickness, and it also permits greater spacing between the buttresses, meaning that fewer are required. [21]

John Eastwood erected his first multiple-arch dam in 1908, and he served as the leading champion of this form until his death in 1924. Eastwood's death did not end all interest in such structures. Fred Noetzli published a lengthy article on multiple-arch dams in Transactions of the American Society of Civil Engineers in 1924, and he wrote a 90-page-long section on this dam type for the final edition of Edward Wegmann's classic study, The Design and Construction of Dams, published in 1927. By 1930, American engineers had designed and built multiple-arch buttressed dams with heights as great as 175 to 200 feet, and with crests as long as 3,160 feet. [22] Some question had been raised about the preservation of their thin-walled concrete arches in high, Western elevations that encountered great temperature extremes, but on the whole these dams had established a good safety record for themselves and had not suffered any catastrophic failures. Nevertheless, concrete gravity and earth-fill dams remained far more popular with American engineers, and in the history of the nation's water resources development, the multiple-arch dam played an extremely modest role. Indeed, as noted by Donald C. Jackson, the leading authority on the history of these dams, by the end of the 1930s they came to be regarded as "cheap, undesirable substitutes for gravity designs." [23]

Late in the 1920s, the engineering firm of Holland, Ackerman and Holland saw the multiple-arch dam as a desirable substitute for a gravity dam. The firm no doubt selected a multiple-arch buttressed dam for Victoria for exactly the same reasons John Eastwood had started building these dams in the likes of California and Utah. Their design saved on materials, and in remote, hard-to-access sites, they could be erected at considerably less cost than more massive gravity dams.

The structure Holland, Ackerman and Holland engineered for the west branch of the Ontonagon rose 120 feet above the river bed and was 300 feet long. [24] It contained about 19,000 cubic yards of concrete and 600 tons of reinforcing steel. It had four arches inclined 45 degrees upstream. In reaching from one buttress to the next, each arch section spanned approximately 75 feet. The concrete forming the arches varied in thickness, being 4 feet wide at the base and about 2 feet wide near the crest. Each arch had a cylindrical intrados with a constant radius of 34 feet 9 inches. The extrados of each arch was conical, due to the arch's variation in thickness from bottom to top.

Tall, reinforced concrete buttresses supported the arches. Some of these buttresses stood in deeper parts of the river valley than others, so they differed considerably in their length at their footings, and in their height. The largest buttress was 138 feet 11 inches long at its base and stood 114 feet high. Like the arches, the buttresses were wider at the base than at the top, varying in width from 9 to 5 feet.

In preparation for erecting the dam, Price Brothers built a concrete mixing plant on the northern side of the river, and on both banks they erected a trestlework that could be traversed by travelling cranes. [25] They also built a temporary high level bridge across the river valley, just downstream of the dam site. The bridge and trestles served two purposes. Primarily, they served to expedite the delivery of materials, especially just-mixed concrete, to work sites. "Mud" from the mixer discharged into bottom-dumping buckets that sat on platform cars. A cable system drew these cars along and across the valley; strategically placed derricks or cranes lifted the buckets off the cars and delivered the concrete to just where it was needed. Secondly, the bridge, trestles, cranes and derricks stood by in case of an emergency. If a freshet swept down the river, they could be used to lift all equipment from the floor of the gorge, thus removing it from harm's way.

In the earliest stage of construction, the contractor paid considerable attention to the floor of the valley -- to the bedrock the dam would stand on. That rock was a rather soft sandstone, laid up in strata from a few inches to several feet thick. Clay-filled seams separated some of these strata, and these seams caused some concern over "the possible seepage of water through ... the rock formations beneath the base of the dam." To guard against this hazard:

...a trench ten feet deep and ranging from four to eight feet in thickness was dug the full width of the valley

immediately beneath the dam and from the bottom of this trench small holes were bored at short intervals from 20 to 30 feet into the solid rock. These small holes were filled with a cement grout under a pressure of 117 pounds to the square inch and the ditch was filled with concrete. [26]

Having tended to the dam's foundation, the contractor started to erect the buttresses and arches, starting in the deepest part of the valley. As directed by the on-site construction supervisor, E. L. Chandler, Price Brothers workers erected the two tallest buttresses first, pouring them in lifts of 12 feet. The contractor used wooden forms "built in panels of convenient size for repeated setting." That is, the same forms were used over and over again. After the concrete had set, the forms were struck and the "panels were easily raised by a small, hand-operated crab gin-pole handled from the top of successive lifts as required." [27] The contractor also carried scaffolding up the sides of the buttresses as they went higher and higher.

After completing the two tallest buttresses, Price Brothers erected the large arch that inclined against them. For forming the interior surface of the arch, which had a constant radius, the contractor used a movable form made of sheet steel that was 15 feet high. For the extrados, "wooden forms were built in panels of sizes suitable for shifting by hand." The contractor laid in the reinforcement between the forms, poured the concrete, and then let it set before raising the forms another 15 feet.

After the tallest arch and its buttresses had been completed, the contractor repeated the process to erect the others. While channeling the entire flow of the river through the power canal leading to the Taylor compressor, Price Brothers erected the dam's three southernmost arches and their buttresses. The contractor left a temporary opening in one of these arches, and then diverted water out of the power canal and back into the natural river bed. This allowed workers to erect the northernmost arch, which stood adjacent the intake structure. In that arch, too, the contractor initially left an opening. The contractor twice more diverted the river's water from the river bed to the canal and then back again, in order to fill in the two temporary openings in the arches.

The dam was nearly complete by November, 1930. Its concrete had all been poured, and forty feet of water had been let up against it, resulting in the discovery of only a few pinhole leaks, which were easily repaired. In completing the dam, the contractor spread a blanket of clay against its waterface to prevent leakage. To protect "the dam against the thrust of ice was considered to be another very real problem in the climate of

northern Michigan," so the contractor installed a system of pipes around each arch at a depth of 12 feet beneath pond level. [28] These pipes discharged air supplied by a compressor housed in the intake structure. The air, as it bubbled up, was supposed to impede the formation of ice against the dam.

The multiple-arch buttressed dam, with its attendant embankments, spillway, and intake structure, created and regulated a reservoir whose drainage basin extended 30 miles upstream and included about 650 square miles of land. The reservoir itself extended about 3 miles up from the dam, and had an average width of 1,000 to 1,500 feet. The reservoir's surface area measured 250 acres, and the dam impounded nearly 10,500 acre-feet of water to be used for hydroelectric power generation. [29]

While completing the dam, Price Brothers built the other major components of the system, starting with the wooden-stave penstock that led away from the intake structure and ran nearly 6,000 feet to the powerhouse. Formed of California redwood, the penstock snaked along the terrain. Ten feet in diameter, and bound up by a total of 1.6 million pounds of steel hoops that wrapped around its circumference every 2 to 3 inches, the penstock sat on concrete saddles mounted about 10 feet apart.

About 350 feet short of the powerhouse, Price Brothers placed an open-pipe "T" in the penstock; above this "T" they erected a Johnson differential-type surge tank -- 30 feet in diameter and with a capacity of 500,000 gallons -- that stood 125 feet above its base. The surge tank offered protection to the powerhouse and its equipment: "...in the event of a sudden check or increase in the water flow the shock will be absorbed by the tank and not by the turbines at the power plant." [30]

For the final steep descent from the surge tank to the powerhouse, a riveted steel penstock replaced the wooden one. The penstock split into a "Y" that delivered water into the scroll cases of twin turbine-generator units. These turbines would operate under a normal head of water of about 215 feet. Victoria Dam provided the first 115 feet of head; the additional 100 feet was gained over the run of the penstock from the dam to the powerhouse.

H. L. Stanger, an architect associated with the engineering firm of Holland, Ackerman and Holland, designed the Victoria powerhouse. The building, with a reinforced concrete sub-structure and a brick and steel superstructure, measured 30-feet by 80-feet in plan and stood 60-feet high above its tailwater. Its lower floor carried two Francis-type, single-runner,

vertical-shaft hydraulic turbines, each rated at 9,000 horsepower. The S. Morgan Smith Co., under a proposal made to the Northern Acquisition Co. on 27 November 1929, provided the turbines and their accompanying butterfly valves, draft tubes, scroll cases, and Woodward-type governors for a total price of \$84,600. [31]

The powerhouse's upper floor carried twin 7,500 kva, 11,500 volt, 3-phase, 60-cycle generators. Allis Chalmers Manufacturing Co. provided this equipment for \$106,034, in accordance with its bid to the Northern Acquisition Company of 30 November 1929. [32] Power went from these generators to a nearby substation, where transformers stepped the current up to 66,000 volts, for transmission to substations located in the villages of Ontonagon and Atlantic Mine. While Price Brothers had been erecting the dam, penstock and generating facilities, another contractor (L. E. Meyer, out of Chicago) had planted some 500 transmission poles between Victoria and Ontonagon and 1,500 poles between the powerhouse and Atlantic Mine, and had strung nearly 200 miles of wire. Since the Copper Range Company was an owner and one of the largest customers of Victoria power, it was fitting that the transmission wire, drawn in Dollar Bay, Michigan, had been made of Copper Range's own copper.

The Victoria hydroelectric plant began serving customers on 2 January 1931. Its power went to a major industrial user in Ontonagon County -- the Ontonagon Fibre Company -- and to several small villages there -- Victoria, Rockland, Mass, Ontonagon, Greenland and Lake Mine. In Houghton County to the north, power went to the mines and mills of the Copper Range Company, and to their associated villages of Painesdale, Trimountain, Baltic, Beacon Hill, Redridge, Freda and Atlantic. In addition, the Copper District Power Company expected to sell upwards of 10 million kw hours of power per year to the Houghton County Light Company. [33]

\* \* \* \* \*

The Copper District Power Company invested about one-and-a-half million dollars in bringing Victoria on line. Victoria was supposedly only the first of seven hydro plants to be erected on the Ontonagon River, but the utility could hardly have picked a worse time to inaugurate operations. Victoria's first few years -- 1931 and 1932 -- were the very darkest of the Great Depression. Copper production at the Keweenaw mines, mills and smelters all but came to a total halt. The Ontonagon Fibre Company cut back its operations and could not pay for the power it used at the full contract rate. The demand for Victoria's power ran far short of its design capacity. [34] The Copper

District Power Company scuttled plans for additional hydros, while generating only 21 to 25 million kw hours per year at Victoria between 1931 and 1934.

The operation ran at a deficit right from the start. By the end of 1931, the president of Copper Range wrote the general manager out in Michigan that "we should absolutely avoid any commitments that will use up cash...It is getting down to a case of every man for himself, and the salvation of each depends on what he can do to work out his own salvation. This may sound like the law of the jungle, but I want to be sure that you get the picture that we have to be absolutely hard-boiled in dealing with ... cash requirements." [35] Copper Range tried to sell off its jointly-owned utility late in 1931, but had no success, and by April 1932 its partner in Victoria, Middle West Utilities, found itself temporarily bankrupt and in receivership. Middle West Utilities reorganized by the end of 1933, and managed to continue its interests in Victoria and the Copper District Power Company.

After several bleak, deficit years, things started to turn around for the Victoria operation and the Copper District Power Company about 1935. The firm made increased sales to the Houghton County Electric Company and to Copper Range, and the Ontonagon Fibre Company was now paying its utility bills again at the full contract rate. Between 1935 and 1940, Victoria's annual power generation nearly doubled, rising from 26 million to 50 million kw hours per year. [36] Instead of running deficits, Victoria's parent company was now earning about \$100,000 to \$125,000 annually, and it started work on a new storage reservoir above the dam at Bond Falls, so that Victoria's flowage could be increased, as well as its generating capacity, now targeted for 60 million kw hours per year.

The operation and profitability of the Copper District Power Company remained steady through most of World War II, but Victoria's power generation dropped in 1945 and 1946 in response to a fall-off in demand. Then, in 1947, a major change occurred in the corporate ownership of the Victoria Dam and hydroelectric plant:

On January 2, 1947, Copper Range Company, together with the Middle West Corporation and the Consolidated Electric & Gas Company, entered into an agreement providing for the organization of the Upper Peninsula Power Company and the sale to it of the shares of the capital stocks of the Houghton County Electric Light Company, Iron Range Light and Power Company, and the

Copper District Power Company, owned by the several parties to the agreement. The Upper Peninsula Power Company was incorporated February 26, 1947 ... to engage primarily in producing and selling electrical energy in Houghton, Ontonagon, Baraga and Keweenaw Counties and the west-central section of Iron County.  
[37]

With the creation of the Upper Peninsula Power Company (also known as UPPCO), the Victoria Dam and hydroelectric plant became one of several power generating facilities owned by this broader-based utility company. UPPCO's holdings included other hydroelectric plants, such as the one at Prickett Dam on the Upper Peninsula's Sturgeon River, a facility engineered and built by the same parties responsible for Victoria, and erected immediately after Victoria. Over time, however, UPPCO's power generation came to be dominated more and more by steam plants, rather than by hydroelectric ones. UPPCO, like its predecessor company, did not erect the several additional hydro plants once planned for the Ontonagon River. It did, however, shepherd Victoria Dam through nearly 45 years of operation, before finding it necessary to replace its multiple-arch section.

Over the course of these years, Victoria's surge tank, steel penstock and powerhouse saw few major modifications; their historical fiber, dating from 1930, remains virtually intact. The same can not be said for the wooden-stave portion of the penstock. In February, 1959, the original wooden penstock ruptured, and before the end of the year UPPCO completely rebuilt the conduit and its supporting saddles. [38] As for the dam, it posed significant maintenance problems for the utility company from the mid-1950s onward. Of particular importance, the concrete in the dam's relatively thin walls deteriorated and suffered spalling problems, due to water leakage and the region's harsh winter climate, which created sometimes large scale temperature differences between the dam's colder air face and warmer water face.

In 1956, "an inspection ... by an experienced diver indicated that on the upstream side of each of the four arches of the dam some portions of the structure have deteriorated to an unsatisfactory condition." [39] UPPCO obtained the services of the Intrusion-Prepakt Company to repair the arches and the flashboard slots at the dam's crest. They drew down the water, cut back defective spalled concrete on both the up- and downstream sides, and then restored the dam's original lines and contours by putting aggregate into wooden forms, which they then pumped full of grout.

In 1963, UPPCO had to replace the concrete walkway along the top of the dam. In 1966, the utility spent over \$160,000 to install new draw-down facilities at Victoria, which could be used to drain its reservoir so that additional concrete maintenance work could be done to its upstream face. In 1971, UPPCO reconstructed the face of the dam, and in 1978 it launched yet another series of "substantial repairs" to Victoria Dam. [40]

None of these repairs proved entirely satisfactory or lasting. In April, 1989, the Dam Safety and Inspection Division of the Federal Energy Regulatory Commission inspected Victoria Dam as part of a nation-wide program to examine all buttressed and multiple-arch buttressed dams. FERC directed UPPCO to submit a plan and schedule for performing permanent repairs to Victoria Dam. [41]

In lieu of once again trying to tackle the problem of stabilizing the old Victoria Dam's concrete, UPPCO, in conjunction with Stone & Webster, opted to replace the multiple-arch section of the dam with a new dam located immediately downstream. This new dam, being erected in the summer of 1991, will "tie into the existing gated spillway...and the existing power intake structure and north embankment...The size and operation of the existing project, including the normal reservoir level, will be maintained." [42] Much of the old Victoria dam, too, will be maintained, but normally it will be out of sight. After the completion of the new dam, workers will remove the top 15 feet of the old dam, and the remainder will be submerged.

Interestingly, this remote, unpopulated site on the west branch of the Ontonagon will continue one tradition, even as Victoria Dam is replaced. It will continue to be the home of civil engineering innovations in the region. First it was home to the highly unusual Taylor hydraulic air compressor; then home to the largest reinforced concrete, multiple-arch, buttressed dam in Michigan, and one of the very few erected east of the Mississippi; and by the end of 1991, it will be home to a new Victoria Dam, this time an RCC dam (roller compacted concrete dam) -- which is the first of its kind in Michigan.

END NOTES

1. See Larry Lankton, Cradle to Grave: Life, Work, and Death at the Lake Superior Copper Mines (New York, 1991), Chap. 3, "The Surface: A Celebration of Steam Power), pp. 41-57.

2. Four of the best sources on this project are: Arthur L. Carnahan, "Taylor Air Compressor at Victoria Mine," The Mining World, Aug. 25, 1906, pp. 206-08; Leroy E. Schulze, "Hydraulic Air Compressors," U. S. Bureau of Mines Information Circular 7683 (Washington, 1954); C. H. Taylor, "Hydraulic Air Compression at the Victoria Mine," Mining and Scientific Press, Aug. 18, 1906, pp. 205-08; and D. E. Woodbridge, "The Hydraulic Compressed-Air Power Plant at the Victoria Mine," Engineering and Mining Journal, Jan. 19, 1907, pp. 125-30.

3. For a more detailed explanation of how the hydraulic air compressor worked, and for a more complete description of its various components (accompanied by illustrations), see the sources listed above in note 2.

4. Lankton, Cradle to Grave, pp. 21, 71-2.

5. Letter, F. W. Denton to W. A. Paine, Feb. 12, 1907. Found in "Power Co.'s" file, Box 1, Van Pelt Collection, Michigan Technological University Archives and Copper Country Historical Collections.

6. "Power Co.'s" file, Box 1, Van Pelt Collection.

7. See J. R. Van Pelt's draft chapter, "Copper Range Electric Company, pp. 4, 7, found in "Power Co.'s" file, Van Pelt Collection; and Schulze, "Hydraulic Air Compressors," pp. 15-6.

8. Ontonagon Herald, Aug. 30, 1930.

9. UPPCO's office of hydroelectric operations contains several of the early studies done on the Ontonagon River. Stone & Webster's "Report of Proposed Hydroelectric Developments -- Ontonagon River, Michigan," is enclosed in a letter to Central Public Service Co of Chicago, Jan. 11, 1927; the Fargo Engineering Company's report is enclosed in a letter from that company to W. H. Schacht, Sept. 13, 1928. Also see J. R. Van Pelt manuscript, "Copper District Power Company, pp. 1-2, in "Power Co.'s" file, Box 1, Van Pelt Collection.

10. Ontonagon Herald, Aug. 30, 1930.

11. Ibid. Also see Ontonagon Herald, May 24, 1930. The original agreement between Copper Range and Middle West Utilities (dated Aug. 17, 1929) is found in "Power Co.'s" file, Box 2, Van Pelt Collection.

12. Copper Range, Annual Report for 1929, p.8.

13. Ontonagon Herald, Aug. 30, 1930; Holland, Ackerman, and Holland, "Report on Ontonagon River Development, June 23, 1928," found in UPPCO files.

14. The best description of the building of Victoria Dam is found in E. L. Chandler, "Victoria Hydro-Electric Development," Civil Engineering, Feb., 1936, pp. 83-7. Chandler supervised the construction as a Price Brothers employee. Also see the Ontonagon Herald, Aug. 30, 1930, and an untitled tour guide to Keweenaw sites, found in Victoria Copper Company file, entry for "Victoria Hydro-Electric Plant," MTU Archives.

15. Chandler, "Victoria Hydro-Electric Development, pp. 85, 87.

16. Ibid., pp. 85, 87.

17. The descriptions of the spillway, intake and embankments are largely drawn from an on-site inspection conducted in April 1991, and from the Stone & Webster report, "Victoria Dam Repair -- FERC Project No. 1864," found in the UPPCO office.

18. Holland, Ackerman and Holland, "Report on Ontonagon River Development," June 23, 1928, p. 44.

19. Ontonagon Herald, Aug. 30, 1930.

20. Donald Conrad Jackson, "A History of Water in the American West: John S. Eastwood and 'The Ultimate Dam' (1908-1924)," unpublished Ph. D. dissertation, University of Pennsylvania, 1986, p. 795.

21. Alfred R. Golze, ed., Handbook of Dam Engineering, (New York, 1977), pp. 445-46; William P. Creager, et al., Engineering for Dams, (New York, 1964), pp. 584-97; Frank W. Hanna and Robert C. Kennedy, The Design of Dams, (New York, 1931), pp. 317-29.

22. Hanna and Kennedy, Design of Dams, p. 329.

23. Jackson, "A History of Water in the American West," p. 769.

24. Stone & Webster, "Victoria Dam Repair," pp. 4-5; Ontonagon Herald, Aug. 30, 1930; E. L. Chandler, "Victoria Hydro-Electric Development," pp. 83-4.

25. Ontonagon Herald, Aug. 30, 1930; E. L. Chandler, "Victoria Hydro-Electric Development," p. 85.

26. Ontonagon Herald, Aug. 30, 1930.

27. E. L. Chandler, "Victoria Hydro-Electric Development," p. 86.

28. Ibid., p. 84. Chandler's article notes that although compressed air continued to be used at Victoria, the original system of air pipes was quickly replaced by a simpler system that worked better.

29. Ontonagon Herald, Aug. 30, 1930; Stone & Webster, "Victoria Dam Repair," p. 6-8.

30. Ontonagon Herald, Aug. 30, 1930.

31. S. Morgan Smith Co.'s "Proposal No. 4903" was found in the UPPCO offices. The utility company also possesses blueprints of the architectural/engineering drawings of the powerhouse. The powerhouse is described in the Ontonagon Herald of Aug. 30, 1930, and in UPPCO's "Application for New License - Major Project Existing Dam - Bond Falls Project," Dec., 1987.

32. Allis Chalmers' "Proposal to Northern Acquisition Company" was found in the UPPCO offices.

33. Ontonagon Herald, Aug. 30, 1930; Copper Range, Annual Report for 1929, p. 8.

34. Annual generation figures and financial data were gleaned from Copper Range's Annual Reports for the 1930s and 1940s; these reports were found at the MTU Archives.

35. Quoted from J. R. Van Pelt manuscript, "Copper District Power Company," p. 11, found in "Power Co.'s" file, Box 1.

36. See Copper Range, Annual Reports for these years; a small section in each is devoted to the operations of the Copper District Power Company.

37. Copper Range, Annual Report for 1946, pp. 6-7. For a brief history of the Upper Peninsula Power Company (UPPCO), see the firm's Annual Report for 1972, p. 4.

38. UPPCO, Annual Report for 1959, p. 1; Daily Mining Gazette, Feb. 28 and March 6, 1959.

39. See the following files maintained by UPPCO: "Hydro Plant -- Victoria -- Maintenance Program, General," which includes the undated document, "Rehabilitation Required at Victoria Hydro Electric Operation," and "Hydro Plant -- Victoria Dam -- Arches and Main Piers -- Inspection and Maintenance of year 1958."

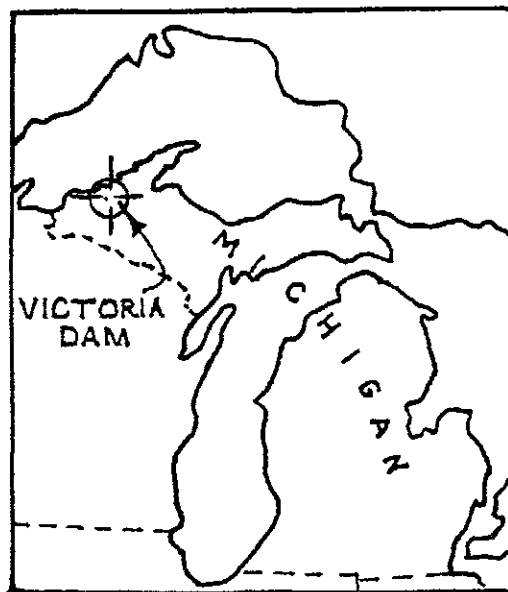
40. See UPPCO file, "Hydro Plant -- Victoria -- 1963 Walkway Replacement, Spillway Work and Concrete Maintenance"; UPPCO, Annual Report for 1966, p. 5; Annual Report for 1971, p. 7; and Annual Report for 1978, p. 4.

41. Stone & Webster, "Victoria Dam Repair, FERC Project No. 1864," Dec., 1990, p. 1.

42. Ibid., p.2.

GRAPHIC DOCUMENTATION

<u>Figure No.</u>	<u>Description/Credits</u>
1	Site plan. Drawn by L. Lankton. Based on earlier site plans provided by Stone & Webster and UPPCO.
2	Sectional view of Taylor hydraulic air compressor, sited just downstream from Victoria Dam. Taken from Leroy E. Schulze, "Hydraulic Air Compressors," U.S. Bureau of Mines, Information Circular 7683, (Washington, 1954).
3	Earlier plan for a concrete arch dam at Victoria, done by Holland, Ackerman & Holland in 1928, and included in their planning study for hydroelectric development on the Ontonagon River.
4	Plan and elevation of Victoria Dam. Taken from <u>Civil Engineering</u> , February, 1936 (v.6, no. 2), p. 84.
5	"Plan-Victoria Dam." Provided by Stone & Webster.



## VICTORIA DAM

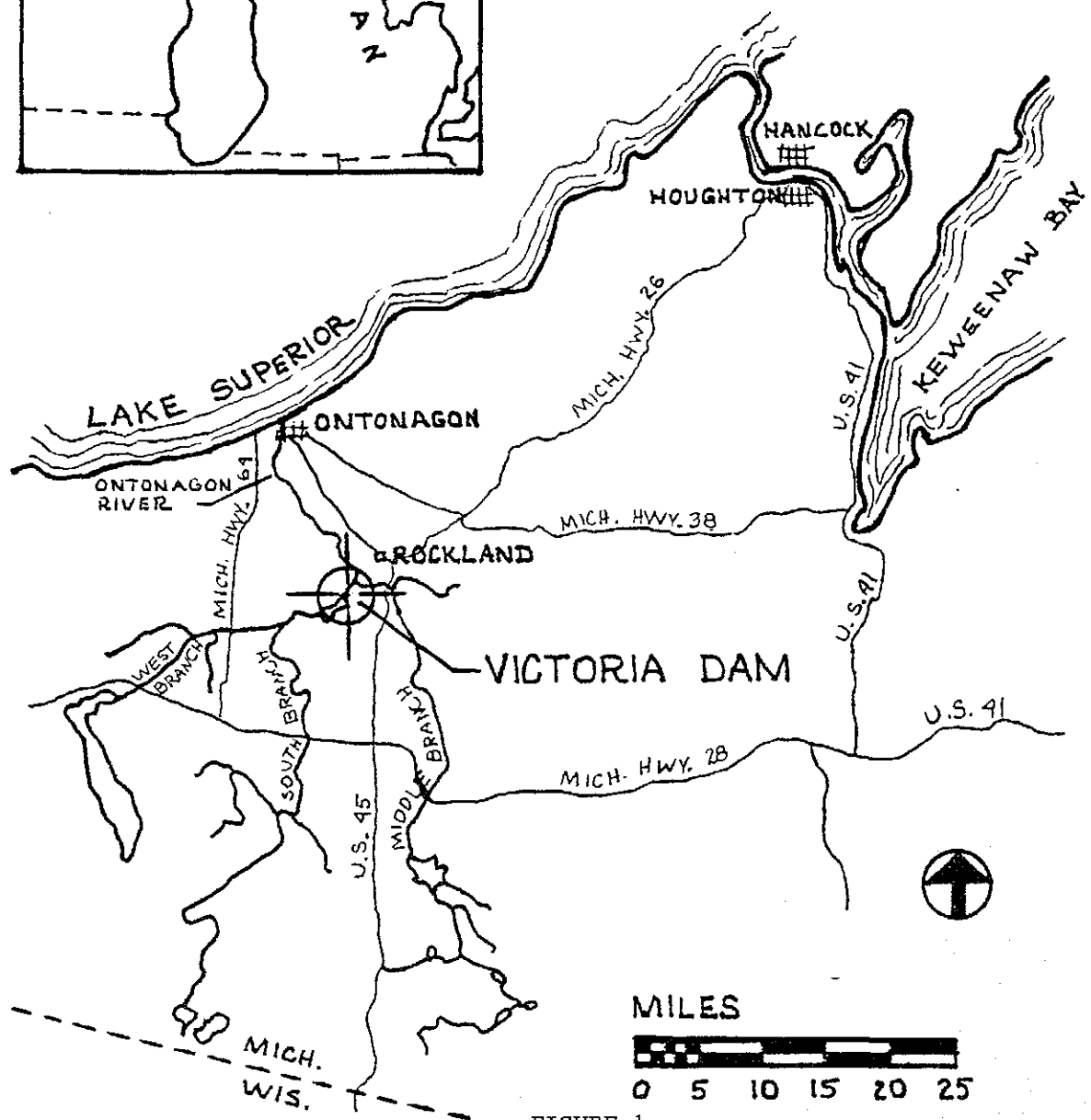


FIGURE 1

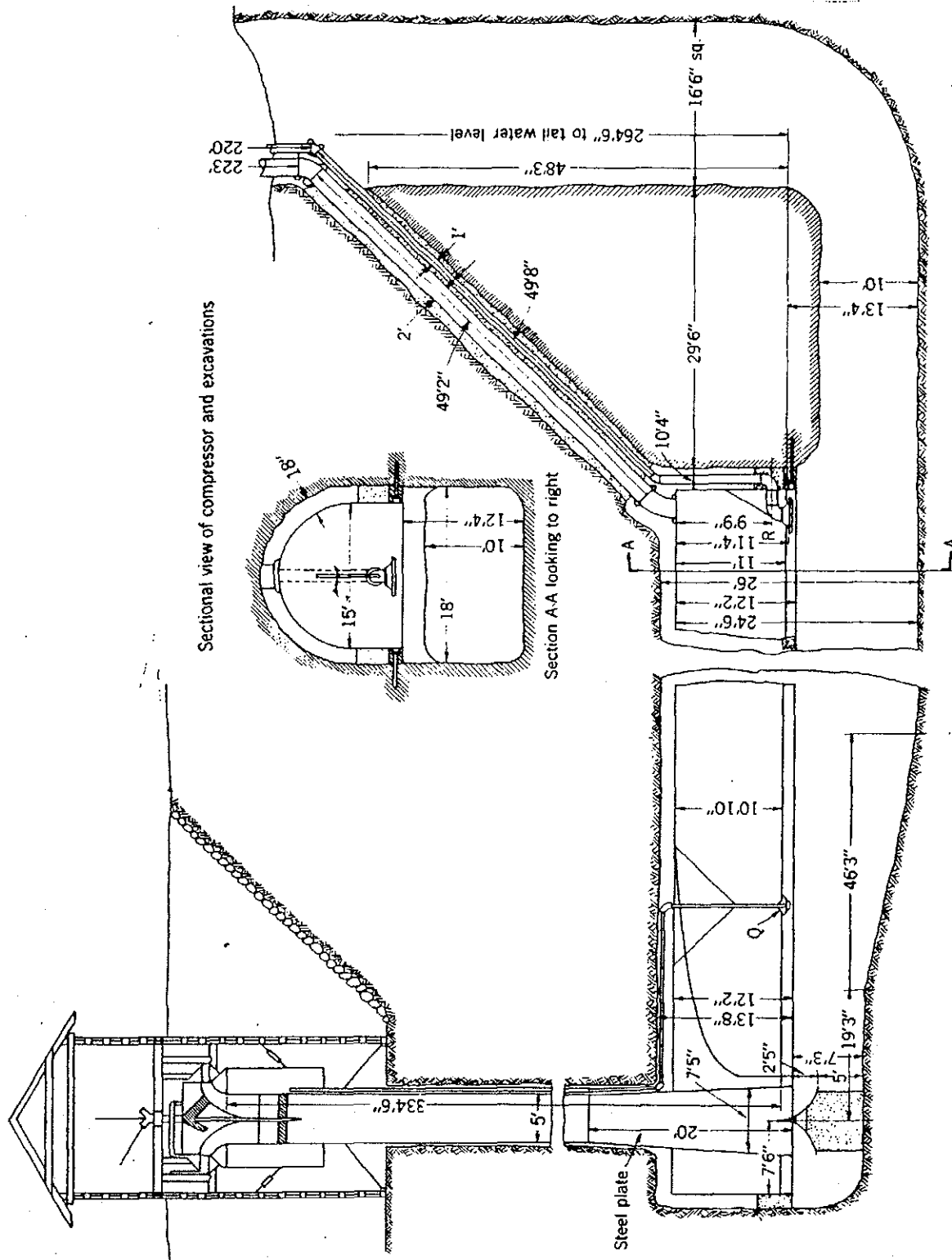


FIGURE 2

Figure 22. - General sectional view of air compressor (drawn by Taylor in 1903).

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PLAN AND ELEVATION OF VICTORIA DAM

FIGURE 4

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